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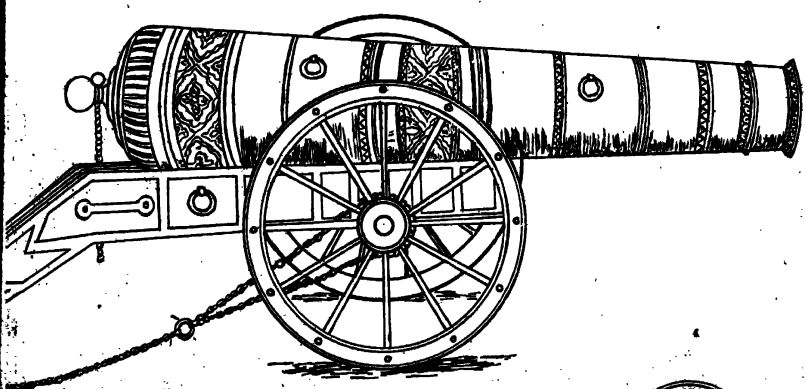
A SIXTEENTH-CENTURY INDIAN SCIENTIST

M. A. ALVI & A. RAHMAN



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INTRODUCTION

The attainments of any man of learning during the medieval period have to be seen in the context of the atmosphere of the period, so different from our own that it is often difficult to visualize what it had been.

Briefly, the most important feature, from the point of view of the development and growth of scientific tradition, was the non-institutional character of education, centred around distinguished men of learning and closely associated with their religious beliefs on the one hand, and the limitation of technology to the level of craft, placed socially low in status, on the other.

Consequently, men of attainments, whether in learning or craft, depended upon the patronage of kings or their nobles—whose fortunes were by themselves subject to uncertainties and generally of short duration—and the zamindars. Hence, the continuity of a tradition, so essential for the development of both science and technology, was an exception rather than the rule.

Men of learning and craftsmen were, therefore, bound in their activity to many subjective factors of their patrons, such as those of religion, language, personal whims and fancies. Consequently only those aspects of science and technology were promoted which were useful to, or fulfilled the requirements of their patrons.

The emphasis, however, was on religious attainments, philosophy and literature. Amongst the sciences, medicine, civil engineering, architecture and astronomy-astrology, in view of their practical significance and use, were both respected and encouraged. Craftsmen were also honoured, but this was a different type of recognition. Their status was not that of the men of learning.

Against this general background of medieval trends, the latter half of the sixteenth century stands out in relief. This was the age of Emperor Akbar. He had a mind radically different from the mind of the age. Enlightened, liberal and rationally disposed, under his long, well established rule clerical authority receded to the background, science flourished in an unprecedented manner. It was with his court that Shah Fathullah Shirazi was finally associated, and where his hitherto dormant potentialities, as a man of science, found expression. Unfortunately, he was associated with Akbar's court for only seven years, as his career was cut short by an early death.

Fathullah was a versatile genius. "If the old books of wisdom had disappeared", says Abul Fazl, "he (Fathullah) could have laid a new foundation (of knowledge) and would not have wished for what had gone"[1]. He specialised in many subjects—

1. *Ak. Nam.*, Beveridge III, p. 593.

theology, literature, grammar, philosophy, medicine, mathematics, astronomy, astrology, mechanics, talisman and magic[2]. Emperor Akbar mourned his death in these words: "Had he fallen in the hands of the Franks, and they had demanded all my treasures in exchange for him, I should gladly have entered upon such profitable traffic and bought that precious jewel cheap"[3].

In the context of the medieval tradition marked by lack of continuity, the sudden flowering of the genius of Shirazi and his attainments raise significant questions for history of science in India.

Firstly, what was the source of his inspiration and the actual content of his achievements? Did he borrow from the Greeks or from the developments in West and Central Asia? Was his work a mere reproduction of the past? Had he something to contribute by way of extension of the then known developments or had anything new to say?

Secondly, why this line of activity having impressed his contemporaries so much was not developed further?

Fathullah Shirazi's attainments do suggest that given the necessary incentive, Indian genius could be directed to 'mechanical arts' and could contribute significantly to inventing mechanical gadgets in the medieval context. The developments in civil engineering and architecture are other examples of this on a greater scale. If Shirazi is an isolated example, and not a tradition, it is a phenomenon which has to be studied.

In this monograph some light is thrown on these problems.

Fathullah was born, brought up and educated at Shriraz. In early youth he came under the influence of a spiritual recluse, Mir Shah Mir by name. Soon he acquired a taste for learning. Khwajah Jamaluddin Mahmud, pupil of the well known logician Jalaluddin Dawwani, initiated him in logic and philosophy. From Mir Ghayasuddin Mansur he learned medicine, mathematics and other sciences. He also studied philosophy in the school of the Zoroastrian intellectual Azar Kaiwan[4]. He seems to have adopted teaching as his first career in Shiraz. Among those of his students who later rose to prominence were Mir Taqiyuddin Muhammad, Afzal Khan, Grand Vazir of Ali Adil Shah I of Bijapur (1558-1580), Rafiuddin Shirazi, steward and historian of the same ruler, Shaikh Hasan Mausali and Fariduddin Masud bin Ibrahim Dehlawi, the compiler of Zij-i Shahjahani, Abdur-Rahim Khankhanan, the well known General of Emperor Akbar and the learned patron of scholars and poets, took lessons from him in mathematics[5].

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2. Bad., W. Haig III, p. 216 and Lowe II, p. 325; *Tar. Bij*, p. 132. Numerous other references are extant in the sources mentioned in this article.
3. *Ak. Nam.*, Bev. III, p. 848.
4. See appendices I, II, III,
5. Abul-Fazl secretly studied mathematical and physical sciences and philosophy from Mausali. However, Abul-Fazl angered him by not giving him respect in open and so he left India. *T. Sh.* f. 345 a. For biographical notes on Taqi see *Dar. Ak.* p. 683, *S. Sadiq*, f. 407 a; Afzal Khan, proper name Ghayasuddin Maqsud see *T. Muluk*, f. 52b, 54 a, 63 b to 67 b, for Rafiuddin, introduction to *T. Muluk*; for Farid, *N. Kh.* vol. 5 p. 306 and for Khankhanan, See *M. Rahimi*, vol. 2, p. 550.

As an exponent of Shiah theology Fathullah's reputation soon spread in the Islamic world. His commentary on the Quran was acclaimed to be the best of the time[6], and before he arrived in India he had already served the ruler and nobles of Iran in the capacity of a religious dignitary[7].

Fathullah came to India after repeated invitations had been sent to him by Sultan Ali Adil Shah I of Bijapur, who gave a fabulous amount of money to cover his expenses for the journey[8]. The date of his arrival in India has not been mentioned by authors.[9] He lived in Bijapur for a pretty long time until the death of his patron in 1580. In 1583 he accepted an invitation from Akbar and joined the Mughal Court at Agra[10].

The account of Fathullah's life in the service of Akbar has been fairly well recorded by contemporary chroniclers—chiefly by Abul-Fazl and Badaoni. He was appointed to the office of *Sadr*. For practical purposes this office had lost much of its importance, since the *Sadr* was left to cater to the religious grants only. However, it did not mean any reduction in the prestige traditionally associated to this dignified office ; but the idea probably was to leave Fathullah with enough leisure and to utilize him for the multifarious duties he was capable of performing. The following New Year's Day, when the Fancy Bazar was held, he put up a splendid show in his stall with several mechanical contrivances all at work at the same time[11]. In the same year (1584) he calculated the so called Ilahi era. Next year the Emperor made him *Aminul-Mulk, i.e.* the trustee of the State, and issued the order that Raja Todar Mal conduct the affairs of the revenue department according to his counsels, and that the "Mir should bring to conclusion the old transactions which had not been examined since many years"[12]. Fathullah accomplished this task with great diligence. Within one year, all the accounts had been checked and errors set right. He made twenty recommendations which were accepted by the king; and by their implementation, Abul-Fazl states, "the tribunal of the vazir became a house of delight for the public." He also examined the currency and found discrepencies in the rules governing coins that ran short of weight on account of their excessive use in circulation. The intrinsic and bullion values of the coins were regulated[13]. In 1585 and again in

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6. But according to Badaoni, next to the commentary by Mirza Jan Shirazi who had been Fathullah's classmate in the school of Maulana Jamaluddin Masud (W. Haig III, p. 216).
7. That is how the present writer interprets Badaoni's statement: سنهای حکام واکابر فارس بود ملّتها (Bib. Ind. III, p. 154). This has been translated by W. Haig as "He was for a long time the spiritual guide of the rulers and nobles of Iran" :
8. T. Muluk, f. 67 b; *Ak Nam.* Bib. Ind. III. p. 991.
9. See appendix IV.
10. *Ak. Nam.*, Bev. III p. 578.
11. Bad., Bib. Ind. II. p. 321, & Lowe II, p. 331.
12. *Ak. Nam.*, Bev. III, 687
13. For revenue and currency reforms see *Ak. Nam.*, Bev. III. pp. 687-693 and Bloch. I, pp. 33-36.

1587 the king selected him for leading diplomatic missions to the Deccan. He was honoured with the title of Azudud-Dawlah or the arm of the emperor, a horse, a purse of Rs. 5,000, a robe of honour and the office of the Chief *Sadr* of Hindustan. Unfortunately, two of his lieutenants, who were old enemies, precipitated a situation on the way which had "nearly brought disgrace to the empire". However, through the good offices of *Azudud-Dawlah* all ended well, but the mission proved fruitless. In 1588 Fathullah accompanied the king to Kashmir. There he fell ill and died. He was ordered to be buried on the Koh-i-Sulaiman where he lies in a tomb by the side of Sayyid Abdullah Khan Chogan Begi in the monastery of Mir Sayyid Ali Hamadani.[14] Four years earlier he had been married to the youngest daughter of Muzaffar Khan Turbati, *Diwan* of the Empire, at the instance of the king.[15]

Fathullah's reputation as a scientist mainly rests on the mechanical devices—a machine for cleaning gun-barrels, a wagon-mill, two cannons, a carriage and a solar calendar known as the Ilahi Calendar. Unfortunately, he left no works of his own. We have to depend on information entirely on the historical and biographical sources, chief of them being the *A'in-i-Akbari* and the *Akbar Namah*. These sources, however, contain only passing references "so that the people should know of their existence". From the technical point of view they contain almost nothing worthwhile. The only redeeming feature is that Abul-Fazl has given the drawings of some of these devices in the *A'in*. These drawings, reproduced in the present study, give a fairly accurate idea of their construction and working. A detailed account of the Ilahi Calendar is however available.

It is interesting to note that Abul-Fazl has ascribed the invention of these machines to Akbar. To what extent his royal patron deserves the credit is difficult to imagine. Yet, even to the most cursory reader, it would be clear from their construction that these were the works of no layman, but of an adept in mathematics, mechanics and metallurgy. That the man was none other than Fathullah Shirazi is proved by some references occurring in the *Muntakhab-ut-Tawarikh* of Badaoni and the *Tabaqat-i-Akbari*. The point has been discussed in a separate note.[16]

INVENTIONS

The Machine for Cleaning Gun-Barrels called Yarghu

According to the *A'in* this machine consisted of a wheel turned by a single

14. The circumstance of Fathullah's death has been differently described by Badaoni at two different places. At one place (Bib. Ind. II, p. 369) he says that he (Fathullah Shirazi) developed a burning fever in Kashmir and since he himself was a skilled physician he treated himself by eating a thick pottage, and however much Hakim Ali (Gilani) forbade, he would not be prevented. So "the executioner of death seized him by the collar and dragged him off to the eternal world". Writing about Hakim Ali Gilani (Bib. Ind., III p. 167) Badaoni says that it was he who prescribed the thick pottage which caused his death. Needless to say that Badaoni was happy with neither of the two.
15. Bad., Bib. Ind. II. p. 316.
16. See Appendix V.

bullock and it cleaned sixteen gun-barrels simultaneously.[17] The drawing given by Abul-Fazl is by no means complete. The inner-mechanism is left to conjecture (Fig. I & II).

It is a huge, eight-legged installation probably all made of iron and steel, may be about eight feet high. An octagonal frame, probably of angle-iron is mounted on top. Half way between the rim and the centre is a toothed wheel (with spokes not shown in the drawing) with the hub fixed on a central vertical shaft or axle, which

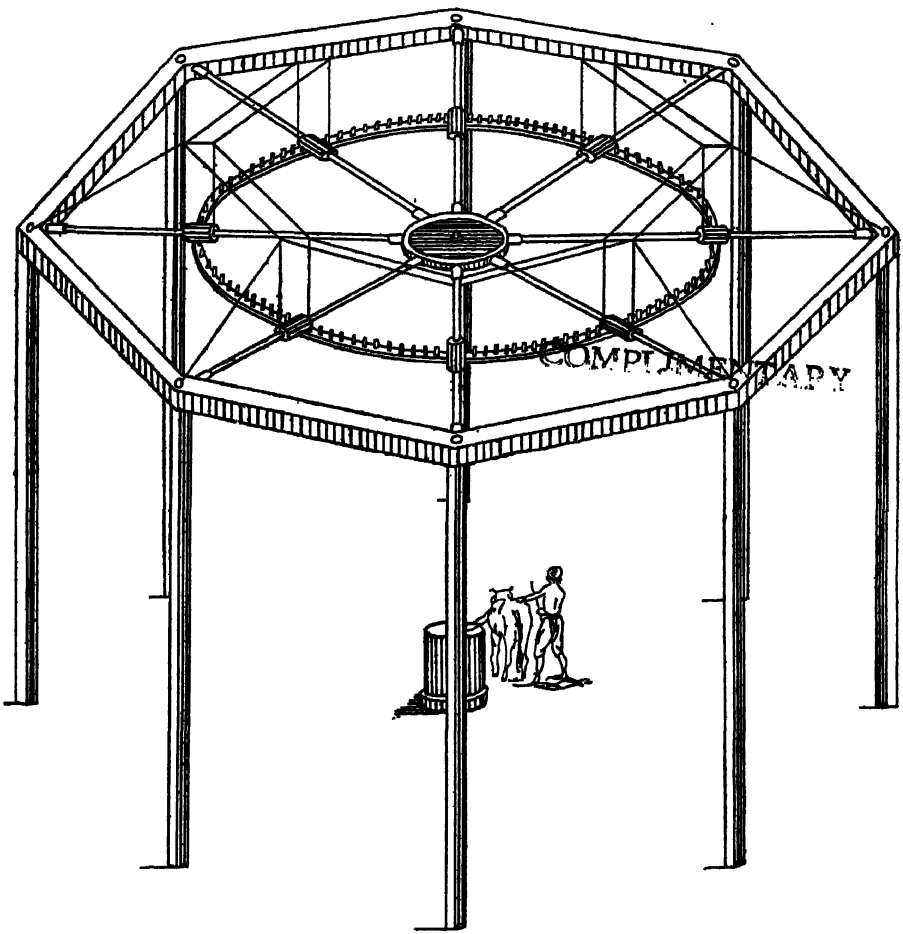

Fig. I
YARGHU
Machine for cleaning gun-barrels

17. *Ain* S. S., pp. 89-90; Bloch II, p. 122; *Tab. Ak.* II, p. 457, *M. Umara* Bev. I, 545, Text, Bib. Ind. I, p. 104.

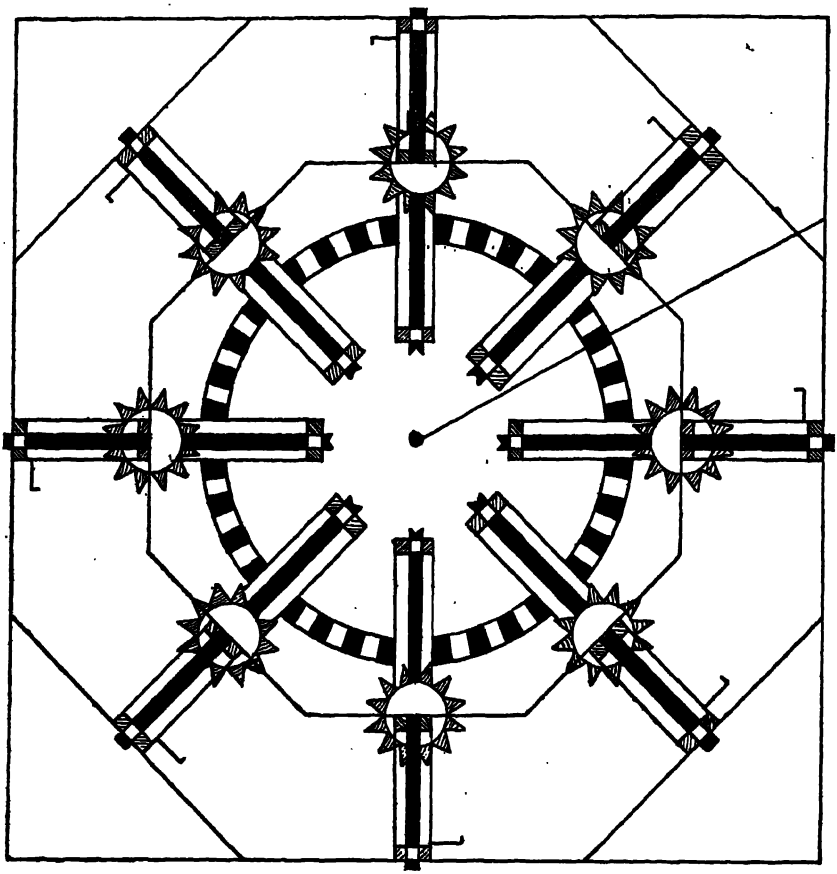

Fig. II
Details of the main mechanism of
YARGHU

rests in a thick casing fixed in the ground. Round the hub, and probably extending some length below it round the shaft, is what appears to be some sort of fixed bearing. On the surface of the bearing are eight sockets facing eight others in the angles of the octagon. The detachable part of the machine consists of eight bars. Each bar is a composite structure consisting of a pinion and two brush-rods of equal length screwed or welded to either sides of the pinion. When the barrels are required to be cleaned they are slid over the brush rods, lifted up to the frame and placed in the sockets provided in the frame and the fixed bearing (Fig. II), the teeth of the wheel being in mesh with the teeth of the pinion.

This machine is worked by a bullock which rotates the axle at the base. The axle turns the wheel which turns the pinions and the latter rotates the brushrods inside the barrels.

The drawing also shows some sections of flat bars across the rods, to hold the barrels in position.

This seems to be what can be called the only plausible explanation of the working of the machine in the light of the drawing.

There are a few points which remain unexplained. For instance, we do not know the type of bearing used. As it is, the machine appears to be a fine specimen of craftsmanship.

The Wagon-Mill

A less complicated but equally interesting device of Fathullah's invention was a mill for grinding the grain. Unfortunately, the *A'in* does not contain its drawing. According to the sources it consisted of a pair of millstones fixed on the plank of a carriage. It worked of itself and ground all sorts of grains when the carriage was used for the purpose of travelling.[18] Yet even with this little information and some stretch of imagination, the actual construction and form can be understood with accuracy. The actual device would not be much different from what has been depicted in figure III. It is a common carriage with a plank, spacious enough to hold a pair of millstones and a few sacks of wheat and flour. Towards the end of its axle is a pinion. Its teeth mesh with those of a cogged wheel, hanging horizontally by a vertical shaft. This shaft passes loosely through the holes provided in the plank and the middle of the stones till it rises a few inches above the upper stone. At the apex of the shaft is a cross-bar with a peg at either end. The pegs fit in the two holes provided near the circumference of the upper stone. The movement of the carriage rotates the upper stone through the pinion, the cogged wheel and the shaft. Thus the wagon-mill is a combination of two separate sets of mechanisms, the carriage and the gear. Power is obtained from the animal.

Travelling Bath

More than anything else, Abul-Fazl seems impressed by the ease with which the above devices could be worked by the minimum animal power. It has been seen how the machine for cleaning guns was easily brought in motion by the efforts of a single bullock. Similarly the wagon-mill could be easily pulled by a yoke. In the travelling bath of Fathullah's invention this point is emphasised further.

This is a two-storeyed wooden structure, with a number of apartments of different types to suit various purposes[19].

18. *Tab. Ak.* Bib. Ind. II. p. 457; *Ain*, Bloch. Vol. I. p. 285, Ain 20; *M.Umara*, Bev. I, p. 545. The author of *Darbar-i Akbari* calls it windmill (edition 1910, Nawal Kishore, p. 681). But there is nothing in the sources to suggest such a possibility. Besides, a phenomenon such as this would not have escaped the pen of Abul-Fazl.
19. *Ain* S.S., p. 158. May be more stories. Abul-Fazl makes no. such statement, but it is quite evident that a carriage of this descritiponcould only be constructed to have two or more stories. Note the line: دیوان بندگی انجام گرفت که گوناگون خانه های گرما به برخوازان آباده شد

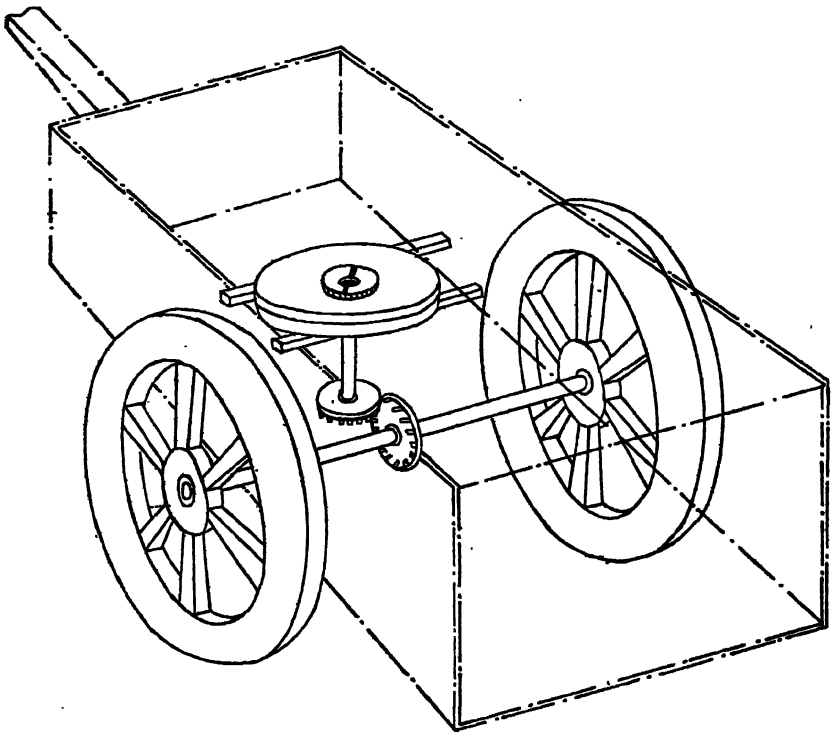

Fig. III
THE WAGON-MILL

It appears to have been made for the use of the king and his family, and must have contained all the paraphernalia of a luxurious bath : dressing rooms, bathing rooms, water-containers, heating and other equipments, furniture, tubs, vessels and room enough for a host of attendants[20].

A quaint illustration of the builder's ingenuity, the vehicle must have aroused great curiousity by the sheer massiveness of its structure. No wonder that an elephant was harnessed to it. But "the marvellous thing about this carriage" is, Abul-Fazl declares, "that it can be easily drawn by a bullock, as well as by a camel or a horse."[21]

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20. Note the phrase حمّامِ تجمّل i.e., luxury bath; and to expand on the meaningful brevity of Abul-Fazl's writing, it implies a bathroom with all the paraphernalia of a luxurious bath. Ibid.

21. Ibid.

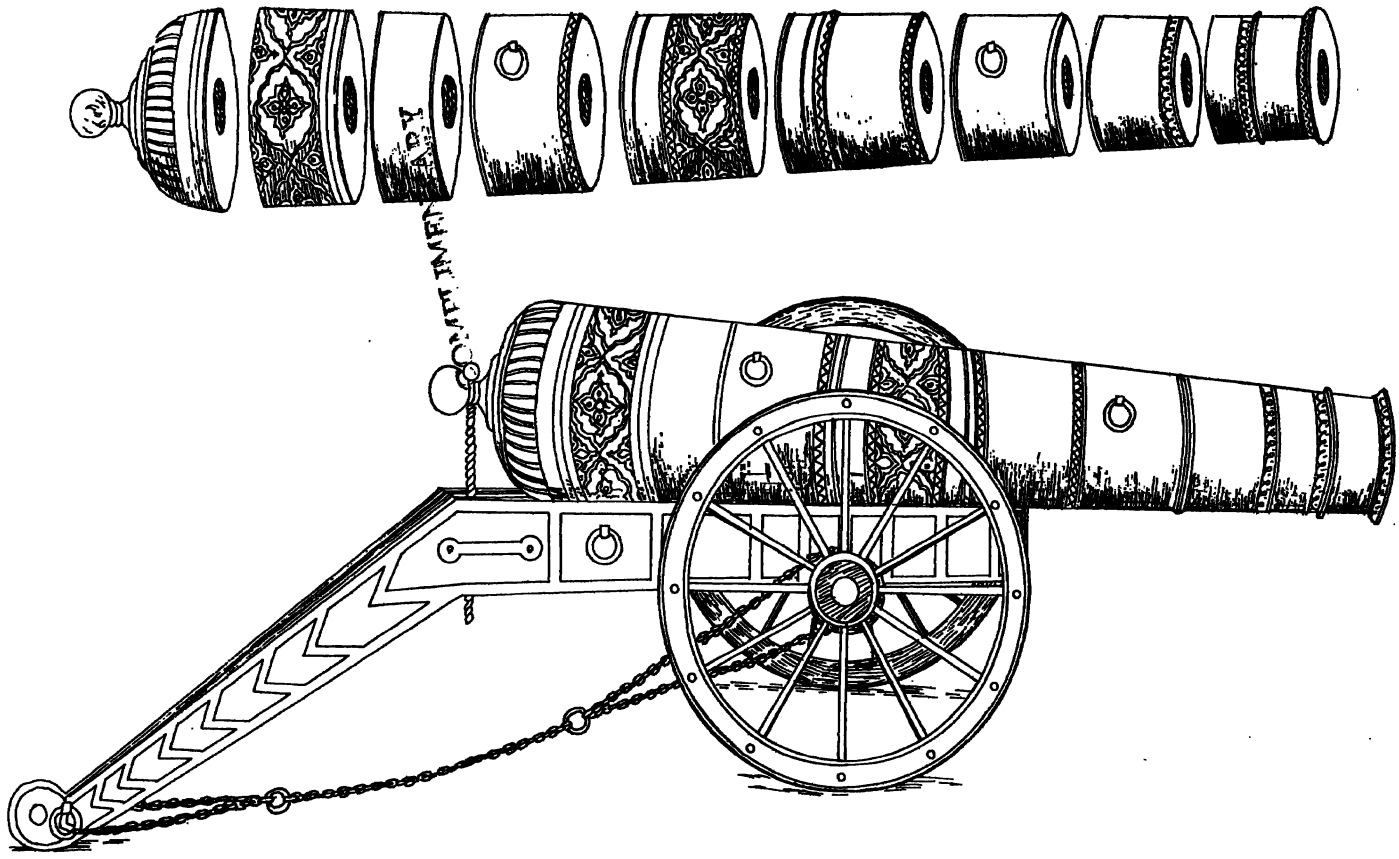

Fig. IV
THE PORTABLE CANNON

Cannons

Two very interesting devices of Fathullah's invention were a portable cannon and a gun which comprised seventeen barrels[22]. The former, used as a light piece of artillery, was made up of five parts screwed one into the other (Fig. IV). Mounted ordinarily on a light carriage, the parts of the gun could be separated and easily carried on top of a hill and rejoined for use. Yet a greater advantage of it lay in its easy portability during post-haste expeditions. The emperor had several pieces of them and made use of them where the heavy artillery would prove to be a liability.

The latter could be rightly called the forerunner of the modern machine-gun. All the barrels were cast or welded in a row so that they could be fired in quick succession by a single match-cord (Fig. V). A huge elephant drawn cart was used as its mount. For battering forts and breaking the concentrations of outnumbering enemy there was nothing like this gun[23].

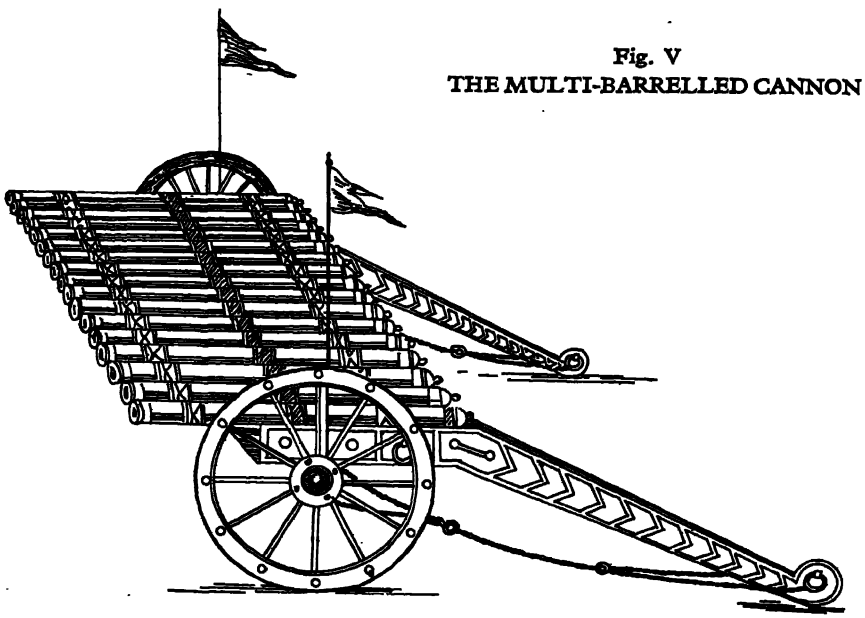

Fig. V
THE MULTI-BARRELLED CANNON

Discussion

Fathullah's innovations involved the discovery of no new mechanical principles. The gear was known to the Greeks in all its three forms—star, crown and worm.[24]. Its

22. May be twelve initially but latter improved by Akbar to make one with seventeen barrels. This may be one explanation of the ambiguity in Bakshi's description in the light of Abul-Fazl's ascribing the invention to the Emperor. See appendix 5.
23. See Appendix VI.
24. Lynne White Jr., *Medieval Technology and Social Change*, Oxford 1962. p. 79.

The Persians had a similar system, except that they used wind as the prime source of power. They developed their mills between the 9th and 14th centuries. Extensive accounts of these are found in the narratives of Arab geographers.[32]

Needham speaks of a Chinese wagon-mill having been invented as early as 340 A.D.[33] Like Fathullah's device it ground corn when used for travelling purposes. This striking similarity may not be purely incidental but it is certain that he had no direct access to it. Not long after its invention it had gone into oblivion, and even if it existed in records he had no approach to them.

It seems, in fact, that the world outside the western borders of China was absolutely unaware of the existence of such a device, till a similar one was made in 1580 in Europe. Needham says that except for the fact of being predated, there is no adequate evidence to show that the Chinese device was in any way related to its western counterpart.[34]

It might be argued that Fathullah may have derived his apparatus from the European wagon-mill, but again there is no evidence to confirm such a possibility. Contact between India and Europe had acquired some magnitude with the advent of the Portugese, but it seems highly improbable that within the short period of three years which separates them chronologically the knowledge of the European wagon-mill could have reached India.

Most probably the later devices had no connection with the Chinese wagon-mill. Similarity in form is not necessarily indicative of genetic sequence, for, given equal knowledge of the fundamentals of a common problem, two or more people are quite likely to find a similar answer.

However, the fact that after a lag of twelve centuries the mills of Europe and India suddenly grew in an almost simultaneous manner, suggests the possibility of their being derived from a common source. If this source was the same as the Chinese wagon-mill, it may have got transmitted sometime during the seventh to the tenth centuries when contact between China and Central and West Asia were particularly close.

Fathullah picked up mechanics where it had been left in the thirteenth century. His work was more in the nature of adaptation than of invention; his method empirical, direct and practical. One should not therefore expect sensational discoveries from him. Yet his devices were not merely tame reproductions of the past. They exhibit a large degree of novelty, imagination, refinement and improvement. The use of the gear-wheel for instance was hitherto confined to the mill and water-raising

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32. See Appendix VII.

33. Needham, *Science and Civilization in China*, Vol. I, Camb., 1954, p. 100. Note (e). We are told that the inventors, Hsieh Fei and Wei Meng-Pien, made it for the Hunnish (later Chao) dynasty. For illustration and description of the Chinese wagon-mill see Ibid, vol IV, part 2 (published 1965.) pp. 255-57.

34. ibid., vol I, pp. 240-241 and 242, Table 8; *A History of Technology*, Vol. II, p. 270.

apparatus and no effort seems to have been made to improve upon it by applying it to other purposes. This was apparently the result of unimaginative adoption of Hellenistic uses. Fathullah's application of it to the machine for cleaning gun-barrels was a demonstration that it was not only a part of specific machines but a principle in itself which, with some use of imagination, could be fruitfully utilized for various other purposes.

The machine for cleaning gun-barrels was the most ingenious of his devices. It embodies in a much more refined and complex form the basic idea of which the travelling mill was a crude expression. Incidentally the essential system of this machine constituting several pinions (diametrically juxtaposed) formed part of Leonardo's design of the hammerwork to prepare metal for coinage.[35] But it had remained confined in the manuscript. The *Yarghu* was the first machine of its kind. His multi-barrelled cannon was the first embodiment of the idea of the machine-gun. This is a credit generally given to the French mitrailleuse which was not much different from the Indian gun. But it was introduced in the French army as late as 1868 and was first used in the Franco-Prussian war of 1870-71.[36] A less developed multi-barrelled cannon called organ is however observed in Europe in about 1790.[37]

In the portable gun we find for the first time the screw being used as a major contrivance, as also perhaps the first practical demonstration of the idea of endless pipeline contrived with this single mechanism.

35. Usher, *A History of Mechanical Inventions*, p. 234, fig. 74, o.f. Theodor Beck, Geschichte des Maschinenbaues, Berlin, 1900, p. 434, fig. 628.
36. Irvine, W., *Army of the Indian Mughals*, New Delhi 1962, p. 138; c.f. The Oxford English Dictionary, Vol. VI, Oxford 1933, p. 548, under "*Mitrailleuse*". Also see IC. XII (1938) p. 416.
37. Irwine W., Ibid.

the palaces through a labyrinth of water-channels encased in the walls, floors and ceilings.[2]

Our inference that the waterworks may have been the innovation of Fathullah Shirazi rests on three points. First, the enormous quantity of water daily supplied could not have been possibly raised by an ordinary apparatus[3]. It must have required considerable improvement in the mechanism involved, particularly the gear-wheel. The Persian wheel which existed before was in a very rudimentary form, such as those observed by Babar in Dipalpur, Multan and Lahore[4]. The one that Babar himself got made for irrigating his garden was a set of several pitchers tied between too circular ropes to make a chain, a bullock turning a drum with ribs in mesh with long clumsy pegs of a crown-shaped wheel[5]. The whole apparatus was made of wood. It seems improbable that any worthwhile improvement would have been effected upon this before Fathullah Shirazi, more so in the case of the gear-wheel.

The second point which helps in our conclusion is the strong conceptual affinity existing between the milling device connected to this machine and the wagon-mill of Fathullah's invention. It is most obvious that if, as Abul-Fazl's statement clearly suggests, the Persian-wheel and the millstone were both moved by a common power, the only method could have been to link them by means of an additional cogged wheel and a gear[6]. This was exactly how Fathullah did, in the case of wagon-mill.

Finally, with what ease "two or four of these (gigantic) wheels came in motion simultaneously by the efforts of one or two bullocks" is a feature characteristic of the wheeled devices of Fathullah Shirazi, as has been observed in the travelling bath.

Unfortunately, the chronicles afford no evidence enabling us to ascertain even an approximate date of the construction of the waterworks. The foundations of the palaces at Fathpur Sikri had begun to be laid by 1571-72, and the building work continued intermittently until a long time afterwords.[7] It was not until as late as 1601 that the last of all monuments, the Buland Darwaza was erected.[8] But the main buildings had been finished by 1585 when Akbar left for Lahore which virtually became his capital[9].

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2. A plan of these aqueducts and channels is given in *Mughal Architecture of Fathpur Sikri*, Archaeological Survey of India XVIII (3), 1897, pp. 38-40 and 48-52. Facing page 51 is a photograph of the baoli.
3. Not to speak of the number of palaces, fountains and cisterns fed, an idea of the quantity may be had from the fact that in some of the baths there are one to two feet wide openings in the cornices of the ceilings from where water fell with pressure enough to make a cascade.
4. *Babar Namah* II, p. 486.
5. *Mughal Paintings* (Faber Gallery of Modern Art Series), Plate IX; Agra Codex reproduction in Rushbrook Williams' *An Empire Builder of the Sixteenth Century*, S. Chand & Co., Second edition, facing p. 143.
6. The complete line of the text referred to in footnote 1 of this section reads:

   وچناں دولابہا ساختند وگرد دنہا تعبیہ شد کہ انشیب لاخہای دور دست آب بر فراز رسد و آبیای بگردد

7. *Ak. Nam.* II, p. 365.
8. *Mughal Architecture etc.*, op. cit., p. 6.
9. *Ak. Nam.* III, p. 493.

Thus, it appears that the waterworks was constructed sometime between 1571-1585. By the later date, Fathullah had already spent three years in the court of Akbar, and to this period all his mechanical devices belong.

S.K. Banerjee thinks the waterworks must have been taken early in hand, for the reason that the need for the supply of water in great quantities must have been felt with the transfer of the administration to the new city[10]. This is however his conjecture, and the argument does not necessarily imply this particular system of water supply. There could have been other ways to meet this requirement. This is likely, however, that the multistage system was an improvement by Fathullah upon a simple Persian wheel and well which may have been built earlier.

Light Carriage

Among the wheeled devices in Akbar's establishment was also a light carriage. For what mark of technical distinction it has deserved a place in the *A'in* is not clear. Abul-Fazl calls it "*Bahl*" and says that it was the most delicate of all the carriages and could carry a few persons on smooth roads[11]. The implication is that it drove faster than others of its kind. Since, as we have seen, easy mobility was characteristic of the wheeled devices of Fathullah Shirazi, it is probable that it owed its existence to him; or he might have improved one of the older types for some special use.

Mirrors

According to *Tabaqat Akbari*, Shirazi had also "made a mirror, which showed strange figures from far and near"[12]. But that is all we know. It is difficult even to suggest what kind of thing it could have been.

10. A historical outline of Akbar's Darul-Khilafat, Fathepur Sikri, *JIH* 1942, XXI (3), p.201.
11. *A'in*, S.S. I, P. 158.
12. Bib. Ind. II, p. 457.

ILAHI ERA (AKBARI)

For at least three quarters of a century, beginning with the 29th year of Akbar's reign (1584), the Ilahi era served as the basis of the official calendar of the Mughal Empire[1]. Notwithstanding its historical importance however, original or contemporary information on its technical details is limited to the barest outlines. Fathullah has left no works. Indeed, any attempt towards a fuller appreciation of this system warrants first the elucidation and interpretation of the obscure phraseology of Abul-Fazl's otherwise lengthy rhetorical narratives.

Fortunately, the problem has been simplified for us to a large extent by Mr. Hodivala, who is the first modern historian to work out the details in his excellent article published in 1923.[2] But his method is rather cumbersome and involves the testing of a number of Hijri-Ilahi synchronisms extant in the official chronicles. This can now be replaced by our approach to authentic astronomical sources. Some of his conclusions also need to be revised.

Description:

The Ilahi Calendar was a 'true' solar calendar. It was based on the astronomical tables of Ulugh Beg Gorgan (called *Zij-i Ulugh Beg*) then the latest computation of the planetary motions.[3] Accordingly the length of the year was reckoned at 365 days, 5 hours, 49 minutes, 15 seconds.[4] It is defined as the time taken by the sun between his departure from, and return to one determinate point in the zodiac.[5] For the Ilahi calendar this was fixed at the conjunction of the zodiacal signs Pisces and the Aries, that is to say, the vernal equinox was the starting point.[6]

A solar month is defined as the interval of time the sun would take in his transit

1. *Infra*, p.
2. *Historical Studies in Mughal Numismatics*, pp. 11-40.
3. *Ain*, S.S. I. p. 221
4. 10 mts., 45 secs., less than the *artificial* solar year of 365 days, 6 hrs., See *Tashil*, f. 5 b. line 13 from below and f. 8 b. 1.9. from below; *Sharh* f. 9 b., 1. 11, from above. *Taq. Sann.*, f. 40 a, Abul-Fazl's statement that it was 14 mts., 33 secs., less is wrong. See *Ain* p. 218, Mr. Hodivala has also committed the same error, op. cit. p. 12. Footnote 1.
5. *Zij. U.B.*, f. 2b; Ain I, p. 213. That the heliocentric concept of Copernicus was either not known or had not been accepted in India by now is obvious. For the purpose of the calendar however it makes no difference. What is actually important is the position of the sun from time to time in relation to the earth. For practical convenience therefore, we shall base our discussion on the medieval concepts.
6. *Ak. Nam.*, Bib. Ind. II. p. 9, 1. 6 from below. *Nauraus* was celebrated on the day of the v. equinox as is apparent from the opening lines of invariably every chapter of the official chronocles of Akbar and Jahangir. Also see *Taq.*, *Sann.*, f. 51 a, and *Jami*, p. 692.

through a particular sign of the zodiac.[7] The same was true of the Ilahi months. According to Abul-Fazl, the number of days in the Ilahi months varied from 29 to 32.[8]

The names of the months were the same as those current in the Yazdjardi era but were distinguished by the appellation of "Ilahi", affixed to each one of them. *viz.*, *Farwardin Mah-i Ilahi, Urdibihist Mah-i Ilahi*, etc, etc.[9]

There were no weeks, at least Abul-Fazl makes no mention.[10] Instead each day of the month was called by a different name. These were the same as were current in the Persian system with two additional terms, being *Ruz* and *Shab* given to the 31st and the 32nd days.[11] The distinguishing feature of the Ilahi era was that the year had a fixed number of 365 days. There was absolutely no intercalation.

The years were also recorded in duodenary cycles, called *Awan* and sometimes *Dawrah* or *Dawr*.[12] Each year of the cycle had a name similar to that of a month, beginning from *Farwardin* and was distinguished by the appellation of '*Sal-i Ilahi*'. After the lapse of a cycle, these names were repeated. Thus, for instance, the 25th Ilahi year could also be written as the year *Farwardin-i Ilahi* of *Dawr* third.

Formally the Ilahi era was instituted by a royal decree on Rabi I, A.H. 992 March 20, A.D. 1584 (N.S.).[13] We are reminded however that since it had been customary to begin a new calendar with the occurrence of a great event, it was in the nature of fitness that the Ilahi era took effect (retrospectively) from the date of the king's accession, 2 Rabi II, A.H. 963-Feb. 23, 1556. The purpose was to bring the Ilahi and the regnal years in accordance with each other. The lag of twenty six days occurring between this date and the day of the vernal equinox, 28 Rabi II, A.H. 963-March 20, 1556, was annexed to the New Year's day of the first Ilahi year or, as Abul-Fazl would like to put it, "the intervening fraction of time.. was treated as the decorative border to the days of the new year."[14]

After this has been said, an important question remains to be answered. How the excess time of 5 hrs., 49 mts., 15 secs. was adjusted within the space of 365 days so as not to disturb the equinoctial position of the sun? There was no intercalation and Abul-Fazl does not inform us on the specific number of days that the different months were to have.

The answer must be sought in the statement of Abul-Fazl himself. Being so meticulous as not to omit the mention of less important facts, such as the then commonly known names of the months and month-days, it is unlikely that he should leave

7. *Ain* I, p. 213; *Zij U.B.*, op. cit.
8. Ibid., p. 221.
9. *Ak. Nam.* II. p. 9. Abul-Fazl's table is reproduced in appendix VIII.
10. The Persian week-days used frequently in the chronicles do not seem to have been adopted in the Ilahi system.
11. Table in appendix VIII.
12. *Ak. Nam.*, II, p. 10.
13. ibid., pp. 10-13.
14. Ibid., p. 9; Also see V. Smith *Akbar* etc., Appendix C. Christian dates are given there in the Old Style. To convert into New Style, add 10 days.

out the fundamentals of the system.

In fact, one has only to read in between the lines to know that Abul-Fazl means much more than his words seem to convey. It is only a matter of knowing the correct meaning of the term '*Shamsi Haqiqi*' which he has used in connection with the Ilahi year and month.

Now, translated literally and therefore quite erroneously as "true solar", the *Shamsi Haqiqi* character of a year or month implied in medieval terminology, a particular method of computing their lengths in terms of whole numbers of days. The term itself originated with Umar Khayyam who worked out the Jalali calendar in 1077. He laid down the principle that the day on which the sun entered the sign Aries a fraction of time before meridian was to be reckoned as the first day of the Jalali year.[15] Conversely, if the transit took place a fraction of time after meridian the new year would begin after the lapse of that whole day and the previous year would continue for another day. In the same manner the Jalali month was determined by the sun's transit from one to another sign. The year and the month so computed were called *Shamsi Haqiqi* and sometimes *Tahwili Haqiqi.*

This definition of the term was widely understood and has been invariably described in all the astronomical works subsequently compiled in India and Iran.[16] That seems to be the reason why Abul-Fazl does not explain it in the context of the Ilahi era.

It was this system of regular monthly computation which Fathullah had adopted. It was a system of variable month-days. That is to say, the number of days in any month was not fixed but was subject to variation by one day, depending on the transit of the sun into the corresponding sign taking place a fraction of time before or after meridian.[17] Thus, for instance, the third month of *Khurdad*, whose length corresponded to the period of the Sun's stay in the sign Gemini would normally have 32 days to it, but could be reckoned also at 31 days in some odd year when the second month would have 32, instead of 31. Similarly the ninth month could be of 29 or 30 days, the fourth month of 31 or 30 and so on and so forth. At any rate, the length of the year remained fixed at 365. The phenomenal excess time of 5 hours etc., which accrues from the accumulation of small fractions from month to month, continued to be periodically adjusted by a process of automatic addition and subtraction through the years' progress. The equinoxes occurred regularly on the fixed dates and the seasons could be dated with accuracy.

15. *Zij.U.B.* f. 6a; *Sharh* f. 15 a; *Taq. Sann.* f. 40 a; *Jami*, p. 692
16. op. cit., also *Z.M.S.*, f. 4a.
17. According to Mr. Hodivala, the time of the sun's transit was computed with respect to the time of sunset. The error is due to his wrong translation of the word زوال occuring in the *Muntakhabul-Lubab* of Khafi Khan (Bib. Ind. II, p. 215). The word زوال is, in fact, an Arabic term for midday and is commonly used in this sense in Persian and Urdu. See reference quoted in footnote 18 below.

Incidentally, Mr. Hodivala has been wrongly led to the conclusion that the Ilahi months had specific number of days allotted to each of them, on the basis of a standard reckoning of the sun's transit through the respective zodiacal signs; that it was a tentative allotment and the occasional variations observed in the official chronicles are, in fact, deviations from it, necessitated by the marginal changes in the Sun's meridional position.[18]

Mr. Hodivala's conclusion is based on the evidence of *Muntakhabul-Lubab* of Khafi Khan, the historian of Aurangzeb. The king is reported to have suspended the use of the solar calendar (Ilahi) but to have permitted, for technical reasons, that the revenue and financial records could be maintained according to the formulae embodied in the following mnemonic verse.[19]

لا و لالب لا و لا لا ش ش مه است لل کط و کط لل شهور کوته است

This is deciphered to mean that the months are to be reckoned in successive order at 31, 31, 32, 31, 31, 31, 30, 30, 29, 29, 30 and 30 days.

Mr. Hodivala has committed the error of presuming this to be an extension of the Ilahi *Akbari* system. He has failed to recognize that this era had undergone a modification during the reign of Shahjahan. It was Faridud-Din Munajjim, the compiler of *Zij-i Shahjahani* who, preferring fixity in month-days had adopted this formulae, and had done away with the practice of periodic astronomical observation.[20] The new system was known as *Ilahi Shahjahani* era and it is to this that Khafi Khan refers in the passage under consideration.[21]

Unfortunately, the same mistake has been committed by the compiler of the well-known dictionary, *Ghyasul-Lughat* and has been repeated by Thomas William Beale in his Persian epigraphical work, *Miftahut-Tawarikh*.[22] Without any reference to their sources, they have ascribed the formulae to the Ilahi *Akbari* era in explicit terms. Mr. Hodivala has even quoted the former as a source of his information. Neither of these however represent the astronomer's view, and as they belong to the 19th century, their statements cannot be taken as authentic, unless supported by a reliable evidence.

On the contrary, the several astronomical works compiled in the 17th, 18th and 19th centuries which dwell upon this subject show a noticeable omission of any such fixation of month-days.[23] But the most authentic evidence to the contrary is the statement of Abul-Fazl himself, with all its implications and omissions. The

18. Historical Studies etc., pp. 36-38
19. *M. Lubab* Bib. Ind., II, p. 215.
20. *Zij Shah* f. 2b
21. Ibid.
22. *Ghyas*, 1893, p. 324, under the word لل ; *Miftah* p. 169.
23. viz. *Taq Sann.* ff. 50b-51a; *Jami* p. 692; *RTSSQ*, f. 15 b.

reason why he does not mention it is simply that it did not exist in the Ilahi *Akbari* system.

In fact, in a calendar computed on the basis of variable month-days, any tentative fixation such as represented in the above mentioned formulae would be a superfluous provision. It can hold good at the most for one year or two and a similar position may not recur for a decade.

For this reason, the table Mr. Hodivala has prepared for converting Ilahi into Christian and Hizri dates, shows errors of one to two days. This indeed is very close to accuracy. But, for that matter, any formulae evolved on the basis of the above mentioned transit system could be applied for converting Ilahi dates with the reasonable margin of error of one or two days. It is interesting to note that this particular *La wa La* rhyme was first composed by Nasirud-Din Tusi in the 13th century for the *Ilkhani* calendar which he computed for his patron Hulagu Khan.[24] The one adopted in the Ilahi *Shahjahani* era is a modification of this, with the only difference that in the original, the fourth month has thirty two days and the third has thirty one. The difference indicates the positional variation of the sun in relation to the zodiacal signs in two different years, being the years of their computation. That after the lapse of five hundred years (or perhaps two hundred years, as the *Shahjahani* Tables were mostly borrowed from the Gorgani Tables) the difference was so slight shows that the original formulae of Tusi would be as feasible for conversion or retrospective dating by the Ilahi calendar as the later. Likewise, there may yet be a third, a fourth, a fifth or a sixth permutation of the formulae, and a concordance table based on any of these, would give reasonably good results. But none could be accurate for all times; hence the idea of having any tentative standard would have no sense.

Discussion

The Ilahi era exhibits a synthesis of heterogeneous elements traceable to various sources. Nomenclatures were adopted from the Persians. For technical data Fathullah was indebted to the Gorgani tables. The idea of the duodenary cycles was borrowed from the Turkish calendar.[25] G.H. Khare has quoted several adicts of Akbar which show that the Turkish duodenary cycle, with its original nomenclature, was already in vogue and had acquired great importance in the administration of revenue, taxation, payment of wages, land grants, remissions and the keeping of records of crops etc.[26] The earliest of those known to us is dated 1558.[27]

As for the system as a whole, we have seen that the Ilahi calendar was technically not much different from the original Jalali era of Umar Khayyam. But the latter

24. *Kashf* f. 56 b; *Jami* p. 692.
25. See : The Turkish Duodenary cycle and its uses by Mughals of India by G.H. Khare, *IC* 26 (i) pp. 64-76.
26. Ibid.
27. Photograph No. 482, p. 8b, Delhi Fort Museum of Archaeology.

had gone out of use during the life of Umar Khayyam himself and had been replaced by a flat system of 30 days to the month with 5 or 6 intercalated days, in order to have a uniform almanack.[28] Fathullah's work was that of reviving the older system.

At any rate the Ilahi era was frought with numerous defects. It could hardly be called a satisfactory answer to the problem of having a solar calendar without intercalation. The ambiguity of a day in each month, so characteristic of the Hijri system which it replaced, remained. The fractional residue which, like a rumple in the coat, kept coursing to and fro was never completely smoothed out. Only it was kept in check from accumulating to necessitate intercalation. Then, it involved too much dependence on the astronomer, or at any rate, on the almanack. While absolute fixity in the schedules of month-days is impossible to achieve in a calendar, it is of utmost importance that variations occur least frequently and at regular intervals. The case with the Ilahi era was just the contrary.

But the question of computing a calendar is something quite different from any other scientific activity, like a laboratory experiment or solving a mathematical quiz. Given the necessary astronomical data, the task remains to be more of an intellectual exercise, of forging compatibility among incompatibles, rather than a search for a scientific truth. The eternal disparity existing between the two motions of the earth offers practically no scope for evolving an ideal system. Ultimately, the whole question boils down to the quest for the best, to reducing uncertainty to the minimum. It is not surprising, therefore, that even today when the relevant scientific truths about the planetary motions are correctly understood, the need for a perfect, permanent calendar remains unfulfilled. Nor is this a matter of surprise that in the older times when the truths were incorrectly or partially understood, all the possible solutions had been tried and the gains no longer accumulate to facilitate newer achievements in the direction of an ideal system.

Fathullah was not aiming at an ideal system. He realised the futility of any such probe. He would not even go in for fresh observations, perhaps, because he realised that the difference of a few minutes was of little consequence, as long as the fractions kept hanging below the quarter of a day. But, his credit lies in opting for technically the most accurate, if not a very convenient system. Whether or not the choice he made was really the best, is what we have to see.

Fathullah was, in fact, charged with the task of solving a long–standing problem. The inadequacy of the Hijri era for the purposes of maintaining fiscal, administrative and revenue records had always been felt in India and other countries; and though several attempts had been made to replace it by a rational calendar elsewhere, the Turks and the Afghans of India had stuck to it for sentimental reasons. In his introductory note to the Illahi era in the *A'in*, Abul-Fazl makes a sarcastic remark on this orthodox tendency and refers to the king's anxiety for a solar calendar in view

28. *Kashf* f. 56b.

of the aforesaid practical requirement of the state.[29] It was to this end that the Turkish duodenary cycle had been adopted. But it was only a partial arrangement; Fathullah completed the task.

Considering this specific purpose, the significance and the merits of Fathullah's work are more easily appreciated. It must be remembered that, in a calendar like this, the most important elements are absolute fixity in the total strength of the year—free from intercalation—concordance between the rotation of the months and the rotation of the seasons, scope for correct retrospective as well as prospective dating and finally the occurance of feasts, festivals and holidays on appointed dates. Since this was impossible to achieve otherwise, Fathullah sacrificed fixity of the month-days. However, uncertainty was only marginal, confined to one or two months in an odd year.

In this respect the Ilahi calendar was easily the best of all others then in use in India or elsewhere. Indeed, the system of reckoning the months by the transit of the sun in the zodiacal signs was in vogue in India long before the days of Umar Khayyam and he may be indebted to India for this—but the calendar was the first of its kind.

That, in spite of all his resources, Akbar should have had to wait for so long to have such a calendar adds to the credit of Fathullah Shirazi. The real importance and merit of his work may however be judged by the fact that all the other calendars calculated later were either an adaptation or a reproduction of his system. In fact it became inevitable for administrative purposes. We have seen that the Ilahi *Shahjahani* system was very much the same. Later on, when Sawai Jai Singh computed the *Muhammad Shahi* era on the lines of the Hijri calendar for the purpose of revenue etc., a modified form of the *Akbari* system was continued by the name of Ilahi *Muhammad Shahi*.[30] With astrologers the Ilahi era was none the less popular. As late as 1851-52 Fida Husain compiled the astrological table for Wajid Ali Shah using the same method and nomenclature.[31]

29. A'in S.S. I, p. 221; Also see the edict enforcing the adoption of the era, *Ak. Nam.* II, p. 11.
30. *Taqwim* 1268 (A.H.) f. 21 a—see the synchronisms.
31. Ibid. ff. 21b onwards.

Writings

Fathullah Shirazi has left no original writings of his own in science or technology. A part of the *Zij-i Jadid-i Mirzai* (astronomical tables of Ulugh Beg) had been translated under his guidance by Kishan Jotishi, Ganga Dhar, Mahesh Mahanand and Abul-Fazl.[1] It seems that the whole work could not be completed because of his other assignments and sudden death.

Yet, he was a prolific writer. Badaoni says that he has some excellent works to his credit, "but", in his opinion, "next to those of Mirza Jan Shirazi," Fathullah's comtemporary and classmate.[2] This refers to his books in religion and philosophy.

Mohammed Husain Azad tells us that he had written on all kinds of subjects but regrets that the writings are no more extant.[3]

It appears that Fathullah owed his fame primarily to a commentary in the Quran in five volumes, written perhaps, in his early career, in Iran.[4] Its title is not known, unless it was simply styled as *Tafsirul-Quran*. It was certainly not called *Manhaju's-Sadiqin* or *Khulasatul-Manhaj*—the abridgement—both of which were the works of a namesake of his, called Mulla Fathullah Kashani. This mistake has been committed by Azad and the author of *Nuzhatu'l-Khawatir*.[5]

Equally well-known has been Fathullah's *Takmilah-i-Hashiyah*, an extension of Dawwani's commentary on Tuftazani's *Tahzibul-Mantiq* in logic. He also wrote a super-commentary on the same by the title: "*Hashiyah bar Hashiyah ala Tahzibil-Mantiq*".[6]

Fathullah's treatise in metaphysics seems to have stirred up an ugly controversy between two rival sects of religious philosophers. The title of the work is not known. It was written by the order of Ali Adil Shah in answer to a question regarding the physical nature and reality of the heavens, namely whether or not the heavens were penetrable and in what way the communion of the divine spirits with the illumined humans of the earth could be explained.

The controversy occupies a good many pages of *Sharistan-i Chahar Chaman* of the Zoroastrian mystic philosopher, Farzanah-i Baharam, a classmate of Fathullah

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1. *A'in* S.S. I, p. 82
2. Bad. III, p. 155
3. *Dar. Ak.* p. 680
4. *S. Sadiq* f. 407.
5. *Dar. Ak.* op. cit. *N.Kh.* IV, p. 255. The *Manhaj* is preserved in the British Museum. See Rieu. Another good copy of it is available in the Salar Jang Library, Hyderabad. The author's name is clearly indicated in both of these copies.
6. *N.Kh.* op cit. For Dawwani see Appendix I.

Shirazi.[7] Fathullah was however not involved in the debate, and there is nothing in it to interest us. But one thing is notable. He appears to try to evade in ambiguity rather than answer the sensitive question, for personal expediency.

He was also one of the contributors to the monumental historical work, *Tarikh-i Alfi*, being one thousand year's history of Islam. The second year after the prophet's death was assigned to him.[8]

Azad speaks of a treatise on the wonders of Kashmir on the authority of *Akbar Namah*. The reference however could not be traced. He also says that a part of the *Ain-i Tarikh-i Ilahi* was written under his guidance, and this too is pure conjecture.

Incidentally, a very interesting work on mechanical devices is preserved in the State Central Library of Hyderabad, by the title of *Kalid-i Danish*, the key to knowledge.[10] A big colophon added at the end declares it to be the work of "Shah Fathullah Shirazi, who attained great prestige in the court of Akbar Shah and was exalted by the title of Azudud-Dawlah." The caligrapher, who calls himself as Hamidud-Din dates the copy close upon the death of Shirazi.

On examination, the work was found to be a translation of an Arabic translation of a latin original. The text and illustrations of almost all the very interesting and complicated contrivances were found to compare with those of another and more expansive manuscript in the same library, entitled "*Kitab-i Ibliniyyus*", the book of Appollonios (of Perga). A closer scrutiny revealed that the manuscript is spurious.

Appollonios, was a geometrician and his works have had great influence specially in conics. But it is doubtful that he ever wrote a work on mechanics, though a treatise on hydraulics is attributed to him.[11] On the other hand the devices occurring in the manuscripts under consideration would be too remarkable to belong to the 3rd century A.D. Indeed, they would be far in advance even in the middle ages before the times of al-Jazzari (12th-13th centuries), and some, even after him.

At any rate, it could not be the work of Fathullah Shirazi. The devices conceptually differ from those discussed above; nor is there any reference to the latter.

It may be however, that, if it is a translation, it may have been done by Fathullah Shirazi. *Kitab-i Ibliniyyus* reveals no name whatsoever.

7. *Sharistan* pp. 346-353. Also see appendix 4.
8. *A'in* S.S. I, P. 82
9. *Dar Ak.* op. cit.
10. No. Nafais, Nairanjat 301.
11. See Sarton vol. I, pp. 173-175 and vol. II, pp. 10 and 633.

CONCLUSION

The work of Shah Fathullah Shirazi which we have examined in the previous pages, represents only a brief spell of his activity in the year 1584. The major part of his life is wrapped in mysterious obscurity. He is praised by historians, but there is little information about him.

Viewing from the quality of his work however, the impressive fund of ready ideas he had and the promptness with which he was able to translate them into practice, one is inclined to doubt if his earlier life was entirely barren of productive scientific activity. May be, in the deep debris of oblivion, there is still lying a book of his writing, which can throw more light on his contribution.

On the whole, it seems as though science came to him as an added grace rather than an occupation. His source of inspiration was the person of the king rather than any innate urge of creativeness. He is reported to have repeatedly observed with reference to Emperor Akbar, "had he (Fathullah himself) not entered the service of that adorner of plurality and choser of unity he would never have found the path to a knowledge of God."[1] There is a significant remark in Badaoni's *Muntakhab* that he had all the competence to build up an observatory of his own", "Should the king have so desired."[2] None of his writings, save the commentaries (written in the early phase of his career), was undertaken except when one or the other patron was pleased to ask of him.

In this respect, he was not different from others of his time. Almost all scholars were attached to one or the other benefactor, a king, a noble or a zamindar, for whom they wrote and worked.

Indeed, the study of the history of science and technology in medieval India, in so far as it consists in the evolvement of specific lines of development, calls for, among other things, a careful study of the institution of patronage also. It is not to say that it was peculiar to India, but it was certainly different from that in any other period or country.

There were no permanent institutions like the Universities of medieval Europe. The *Madrasahs* with their traditional system of *dars* (teaching), centered around individual scholars, were totally unsuited to the pursuit of any worthwhile research in science, more so in the field of technology. The courts and the elaborate royal *karkhanas* remained the most attractive centers for the scholar and the technician.

The emerging feudal relationship between power and learning had its own

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1. *M. Umara*, p. 546.
2. Bib. Ind. III, p. 155

blessings and drawbacks. Of these, the work of Shah Fathullah Shirazi provides an interesting illustration.

The royal *kharkhana*, for instance, manufactured a wide variety of things required for the use of the royal household and the departments of the State. With all the facilities at disposal and manned by the most skilled technicians available in or outside the empire, these *kharkhanas* represented the highest technical skill of the time.

The fact, that it had been possible here to give shape to the ideas of Shah Fathullah Shirazi, evidences a very high standard of technological know-how. Unfortunately, we do not at present know the techniques which may have been employed specifically for the construction of the devices. However, for the sixteenth century, the casting or forging of the seventeen-barrelled cannon could be called a marvel of metallurgical technique. The manufacture of the devices on the whole must have involved a great degree of precision, standardisation of the material and complicated mathematical calculations.

But these were no academic institutions for objective research in science or technology. Between the patron and the scholar, the tie was of service, not of intellect and fulfilment of particular needs rather than the spirit of investigation characterised by much of intellectual activity. Inevitably, the advancements, if any, could have taken place in limited directions. Fathullah's devices exhibit, for instance, an intriguing emphasis on the requirements of the military—the wagon-mill and the travelling bath included. The Ilahi era was calculated to meet the requirements of the administration. In both cases, the primary gains were of the state. The gains of the sciences of technology or astronomy, were incidental.

For this reason, Fathullah's work was destined to remain as an end in itself rather than a positive contribution. In different circumstances, with continuous, undivided attention to scientific pursuits, his talents might well have borne far-reaching results. In the mechanical devices he displays a remarkably analytical approach. A machine is not only a machine for him, but a complex of essential mechanisms. He can vary their sizes and forms and can apply them from varying angles in varying compositions to suit different purposes. But this does not take him deeper down to the study of the underlying principles of which the mechanisms are material expressions.

From here begins the theoretical study of technology. It involves the awareness to the problems of knowledge, undertaking of experiments to ascertain fundamental truths, the discovery of the laws governing the behaviour of the physical world and finally their application to the solution of these problems. It is not one man's job, but a continuous process, each discovery, each solution, leading to the awareness of newer problems. The role of the individual scientist can be appreciated by the extent of his participation in this process and in terms of its potentialities to influence the subsequent development of scientific thought.

We have no evidence of any attempt on the part of Fathullah Shirazi to have taken up theoretical work. His method rested on empirically matured thought-

processes. Nor do the sources afford us the reason to believe that his work was actually carried further by way of study or improvement.

Yet, not all the great works in history have been inspired or have grown from theoretical method. This, in fact, is a much later development and presupposes a definite level of advancement in technology, at least a certain degree of coherence among the various aspects of a tradition. Empirical processes may mean a slow pace of progress but do not negate the possibility of outstanding achievements, pointing to newer directions. It will be seen, that Fathullah's devices are not entirely devoid of creative potentialities. On the contrary, they are replete with suggestive ideas which, if they had been taken up further, could well have been the basis of a distinct technological tradition. We have seen that the French *mitrailleuse* was the progenitor of the modern machine-gun. So could be the Indian multi-barrelled gun. The *Yarghu* contains distinct suggestions that the mechanism involved could be developed and more fruitfully applied in a number of techniques involving rotatory motion. As one examines the various technical aspects of his devices, a number of possibilities occur to the mind, in which his ideas could be utilized.

As a matter of fact, the whole question of the recognition and subsequent exploitation of the generative potentialities of a work in technology is very much a historical one. What social, economic, psychological or other factors might have been responsible for want of this line of development has yet to be studied. To say anything at this stage would be premature.

APPENDICES

I—Jamalu-d-Din Mahmud, considered to be the intellectual successor of Jalalud-Din Dawwani, excelled in logic and philosophy. He is the author of several standard works and was the teacher of some well-known scholars such as Ahmad Ardabili, Abdullah Shustari, Fakhru-d-Din Sumaki and Mirza Jan. *H. Iq.* Bib. Ind., I, p. 261.

Dawwani lived in 1427-1502 A.D. His *Akhlaq-i Jalali* is still considered one of the best works in classical ethics and Persian literature. It was based on an Arabic original of the 11th century. His other works include *Sharh-i Hayakil* and *Isbat-i Wajib* in metaphysics and commentaries on some works in theology and logic. *H. Iq.* Vol. I, p. 209; *Dic. Or. Biog*, vide Dawwani.

II—Mir Ghyasud-Din Mansur was the son of the well-known philosopher Mir Sadru'd-Din, a pupil of Dawwani. He lived in 1445-1506 A.D., was the author of several works on medicine. *Jam-i Jahan Numa* is also stated to have been written by him. *H.Iq.*, Loc. cit. p. 529. Beale, vide Ghayasu'd-Din Mansur; Badaoni, Lowe, II, p. 325.

III—Zoroastrian saint and scholar of Greek philosophy, Azar Kaiwan, also known by the title of Zu'l-'Ulum (learned in all sciences) was one of the pioneers of the 16th c. *Ishraqiyah* revivalism in Iran. He taught in Shiraz and had a large number of disciples. Fathullah Shirazi is reported to have attended his lectures, though perhaps he never received the baptism. Sometime during the last years of Akbar's reign he came to India and visited several places. He also stayed in Patna for some years.

The *Ishraqiyyah* school of thought believes in the role of spiritualism as supreme in philosophy, somewhat akin to the Spanish *illuminati* of the 18th century. According to Boer, it has its genesis in the syncretic philosophy of Hellenism which "reached the east from Neo-Platonic, Hermetic and allied sources and was there amalgamated with Persian and other speculations." The name *Ishraqiyyun* was however given to the disciples of the Muslim saint As-Suhrawardi (d. 1291) with whom the *Ishraqiyyah* School originated. As distinct from the *Mutakallimin* and the *Masha'in*, the *Ishraqiyyun* start with a "mystical theory of knowledge", *viz.*, human perception of reality involves a process of illumination (*kashf*) from God (who is light) through the intermediary of the "spirits of the sphere" (*Mala'ikah*).

These ideas had given rise to some very interesting controversies during the days of Fathullah Shirazi. In one of these he was himself indirectly involved.

Quotes on *Ishraqiyyun* etc. from *Encyc. of Islam* II, 1927, p. 533, c.f. T.J. Boer Urani in *Ztchr. f. Assyriol* xxii (1912) 8 sqq.; see also *Sharistan--i Chahar Chaman* of Farzanah-i Baharam (a disciple of Azar Kaiwan) Bom. A.H. 1270, A.D. 1853, pp. 229-232 and 347-348 Haji Khalifa ed. Flugal iii, p. 87; Notes on Azar Kaiwan from *Dabistan-i Mazahib*, Bom., A.H. 1262, A.D. 1845, pp. 29-30.

IV—An Urdu author wrongly identifies Fathullah as Tutor of Ali Adil Shah, indirectly leading to the conclusion that his arrival in Bijapur was the event of the reign of Ibrahim Adil Shah, the latter's father. *Maarif* 1938, vol. 41 p. 368. The source of the mistake is obviously the Urdu work, *Waqiat* (p. 199), wherein the author, quoting *Farishta* (Maqalah 3, Roza 2) speaks of one Mullah Fathullah Shirazi Najjar calling him simply as Fathullah Shirazi.

It appears that Ali Adil Shah invited him at the instance of Afzal Khan, his minister and pupil of Shah Fathullah Shirazi. *T. Muluk* f. 67 b. Unfortunately the date of the Vazir's arrival in Bijapur, or of his joining the court of Ali Adil Shah is not known. However, he had been serving the king for some years before 1564 when he was raised to the vizierate. Ibid. f. 66 a. As we know, Fathullah finally left the court of Bijapur after the death of Ali Adil Shah (1580), we can reckon the period of his service here, roughly, as a decade and a half.

V—Of the seven mechanical devices described in the *A'in* five have been included in this section. These are : a machine for cleaning gun barrels called *Yarghu*, a wagon-mill, a portable cannon, a seventeen-barrelled cannon and a travelling bath.

Our inference that these were the inventions of Shah Fathullah Shirazi is based on the following reasons:

(1) Badaoni speaks of an exhibition stall set up by Fathullah in the Fancy Bazar of 1584 where he displayed "all sorts of skills such as *Jarr-i Asqal* and other strange contrivances" of his invention. Bad. Bib. Ind. II. p. 321; tr. Lowe II, p. 331.

(2) Nizamud-Din Bakhshi, another historian of the court of Akbar, author of *Tabaqat-i Akbari* identifies at least two of these as the inventions of Fathullah Shirazi (Bib. Ind. II. p. 457) and this information is reproduced in identical words by Shahnawaz Khan. *M. Umara* Bib. Ind. I,. p. 104; Bev. I, p. 545. One of these is the wagon-mill. His other reference is open to two interpretations. The text reads:

دبیک چرخ دوازده بندوق سرمی شد

(Twelve guns were fired by a single wheel)

Literally interpreted, the line implies that Fathullah had invented a gun which had twelve barrels and that the principal mechanism of this device was a wheel. In other words, it was a twelve-barrelled wheel-lock.

No weapon of this description existed in the Mughal army. Nor is there any evidence to show a Mughal counterpart of the European wheel-lock (invented 1515). It would have been too remarkable to escape the pen of Abul-Fazl.

Again, the multi-barrelled cannon referred to in the *A'in* had seventeen and not twelve barrels and it was ignited, not by a wheeled mechanism but by the simple match-cord system.

The Bibliotheca edition of *Masiral-Umara* shows two variants for the word "*Sar*". These are '*Bar*', '*Pur*' or '*Par*'. But these seem to carry no sense. The Aligarh ms. of the *Tabaqat* (Subhan Collection 954/3, p. 258) shows a third variant, '*Yar*' which, in Turkish, means earth, ground, dust etc. and is used in a number of idioms. Yet again, '*Yar Mishud*', as a Persian phrase would be grammatically invalid. However with indulgence to a possible error by the author in respect to the use of the word چرخ and the number of barrels indicated, the line may be taken to refer to the seventeen barrelled cannon described in the *A'in*. An Iranian biographer has in fact been led to this same conclusion. See Ruknzadah p. 59.

On similar grounds however, the statement can be interpreted in favour of the yarghu—the machine for cleaning gun barrels—as Blochmann (Vol. I, p. 285, note 1) and Beveridge (op. cit.) have done. This machine had a gear wheel as its chief mechanism and could clean sixteen barrels at one time.

Bakhshi compiled the major part of his work during his stay in Gujrat between 1582-1589. (See *Tabaqat*, De, p. ix.) while Fathullah constructed the devices in 1584. It is possible that his knowledge of these machines rested, not on personal observation, or that he depended much on his memory. Quite possibly, therefore, the error may have been the result of a confused association in his mind of the functions and forms of both these devices, especially as a multiple number of barrels was a common factor. At any rate, we conclude and we have all the reason to believe, that the reference includes both among the inventions of Fathullah Shirazi.

(3) The third clue to the identity of the inventor lies in Badaoni's statement. For the exhibits in Fathullah's stall he uses the phrase:

جرّ اثقال وغرائب دیگر

Lowe has translated *Jarr-i Asqal* as dragging about of weights. op. cit. This is too literal to be sensible. The term is used in Persian language in two different senses depending on syntax. (1) the science of mechanics as Wolsey Haig has translated. (Bad. W. Haig III p. 216) and (2) as plural of *Jarr-i Saqil* implying thereby various types of carriages involving transportation of heavy loads and cranes. Thus, the compiler of Farhang-i Anand Raj gives the following definition:

"A science dealing with the principles of pulling and lifting (or carrying:

ton 1927, pp. 638 and 674. *Man the Maker*: New York, 1950, p. 94. *Endeavour*, xv (1958), Muslim Mechanics and Mechanical appliances, p.25.

VIII— **TABLE OF ILAHI MONTHS**

Names of the corresponding zodiacal signs are indicated against each month:

1.	Farwardin	Mah-i Ilahi	Aries
2.	Urdibihisht	„	Taurus
3.	Khurdad	„	Gemini
4.	Tir	„	Cancer
5.	Amurdad	„	Leo
6.	Shahrivar	„	Virgo
7.	Mihr	„	Libra
8.	Aban	„	Scorpio
9.	Azar	„	Sagittarius
10.	Bihman	„	Capricornus
11.	Dai	„	Aquarius
12.	Isfandarmuz	„	Pisces

TABLE OF ILAHI DAYS

1.	Armuz	17.	Mihrgan
2.	Bihman	18.	Sarosh
3.	Urdibihisht	19.	Farwardin
4.	Shahrivar	20.	Baharam
5.	Isfandyar	21.	Ram
6.	Khurdad	22.	Bad
7.	Murdad	23.	Daibadin
8.	Daibazar	24.	Din
9.	Azar	25.	Arad
10.	Aban	26.	Ashtad
11.	Bash	27.	Asman
12.	Khurmah	28.	Zamyad
13.	Mah	29.	Marisfand
14.	Tir	30.	Aniran
15.	Gush	31.	Ruz
16.	Khur	32.	Shab

ABBREVIATIONS

1. *Ain* S.S.	*A'in-i Akbari*, Abul-Fazl Allami, ed. Syed Ahmad Khan, Delhi 1274 A.H.-A.D. 1857, vol. I and III.
2. *Ak. Nam.*	*Akbar Namah*, Abul-Fazl Allami, Asiatic Society *of* Bengal Vol. II, 1879 and III, 1886.
3. *Ak. Nam.* Bev.	*Akbar Namah* Tr. H. Beveridge, Calcutta, 1910.
4. *Bab. Nam.*	*Babar Namah* tr. A.S. Beveridge, Luzac & Co. London, 1922.
5. Bad. Bib. Ind.	*Muntakhabut-Tawarikh*, Abdul-Qadir Badaoni, Asiatic Society *of* Bengal, Vol. II, 1865 and III 1869.
6. Bad. Lowe	*Muntakhab* etc. tr. W.H. Lowe, Vol. II, Calcutta 1889.
7. Bad. W. Haig	*Muntakhab* etc. tr. Wolsey Haig, vol. III, Calcutta, 1925.
8. Bloch	*A'in-i Akbari*, tr. H. Blochmann, Asiatic Society of Bengal, Second Edition 1927.
9. Dic. Or. Biog	*Dictionary of Oriental Biography*. Thomas William Beale ed.
10. *Dar. Ak.*	*Darbar-i Akbari*, Muhammad Husain Azad, Lahore, 1898.
11. *H. Iq.*	*Haft Iqlim*, Amin Ahmad Razi, Royal Asiatic Society of Bengal, 1939.
12. *IC*	*Islamic Culture*: Hyderabad historical quarterly.
13. *Jami*	*Jami-i Bahadur Khani* Ghulam Husain, Calcutta, 1835.
14. *J.I.H.*	*Journal of Indian History*: The University of Travancore, Trivandrum, 1942, Vol. XXI (3).
15. *Kashf*	*Kashful-Haqaiq-i Zij-i Ilkhani* etc. Nizamud-Din Nishapuri, autograph 1309, Raza Library Rampur, Ms. No. Farsi Haiat 1203.
16. *Miftah*	*Miftahut-Tawarikh*. Thomas William Beale, Nawal Kishore, Lucknow, 1868.
17. *M. Rahimi*	*Ma'asir-i Rahimi*, Abdul Baqi Nahavandi, Asiatic Society of Bengal, 1929-1931.
18. *M.Umara*	*Ma'asirul-Umara*, Shah Nawaz Khan and Abdul-Hayy, tr. H. Beveridge, Second edition, Calcutta 1911-41.
19. *M. Lubab* Bib. Ind	*Muntakhabul-Lubab*, Khafi Khan, Asiatic Society of Bengal, Vols. I & II, Calcutta 1869-1870.
20. *N.Kh.*	*Nuzhatul-Khawatir* etc. Vol. IV, Dairatul-Marif Hyderabad, 1904.

21.	*RTSSQ*	*Risalah dar Tahqiq-i Sann-i Shamsiyah wa Qamariyah*, Qazi Najmud-Din, compiled 1796, Maulana Abul-Kalam Azad Library Aligarh, Ms. No. Farsiyah Ulum 25/2.
22.	Ruknzadah	*Danishmandan-u Sukhansarayan-i Fars*, Muhammad Husain Ruknzadah Admiyyat, 1st edition, Tehran, Vol. IV.
23.	*Sharh*	*Sharh-i Zij-i Ulugh Begi*, Abdul-Ali al-Barjandi, Azad Library Aligarh, Ms. No. Habibganj, 44/19.
24.	*Sharistan*	*Sharistan-i Chahar Chaman*, Farzanah-i Baharam, Bombay, A.H. 1270 A.D. 1853.
25.	*S. Sadiq*	*Subh-i Sadiq*, Mirza Muhammad Sadiq, compiled 16th century, Maulana Abul-Kalam Azad Library Aligarh, Ms. No. Subhanullah 75/654.
26.	*Tab. Ak.* Bib. Ind.	*Tabaqat-i Akbari*, Nizamud-Din Ahmad Bakhshi, Asiatic Society Bengal, Vol. II, 1931. (Ms. Subhanullah 954/3, Aligarh)
27.	*Tab. Ak.* De	*Tabaqat-Akbari*, tr. Brijendra Nath De, Calcutta, Vol. II, 1939.
28.	*Tab. Shah.*	*Tabaqat-i Shahjahani*, Muhammad Sadiq, Azad Library Aligarh, Vol. II, Ms. No. Habibganj Farsi 22/46.
29.	*Tar. Bij.*	*Tarikh-i Bijapur*, Ibrahim Zuberi, Sidi Press, Hyderabad.
30.	*T. Muluk*	*Tazkiratul-Muluk*, Rafiud-Din Shirazi, compiled 16th century, Mashriqiyyah Kutub Khana Salar Jung, Hyderabad, Ms. No. Tarikh Farsi 142.
31.	*Tashil*	*Tashil-i Zij-i Ulugh Begi*, Abdul-Ali al-Barjandi, copy 1052 A.H.-A.D. 1642, Azad Library Aligarh, Ms. No. Farsiyah Ulum 27.
32.	*Taq. Sann.*	*Taqwim-i Sannain*, anonymous, compiled 235 A.H.-1819, Azad Library Aligarh, Ms. No. Farsiyah Ulum 125/18.
33.	*Taqwim*	*Taqwim 1268 Hijri*, Muhammad Fida Husain, State Central Library Hyderabad, Ms. No. Riyazi 138.
34.	*Waqiat*	*Waqiat-i Mamlukat-i Bijapur*
35.	*Zij Shah*	*Zij-i Shahjahani*, Faridud-Din Masud b. Ibrahim Munajjim Dehlawi, Raza Library, Rampur, Ms. No.1218.
36.	*Z.M.S.*	*Zij-i Muhammad Shahi*, Mirza Raja Sawai Jai Singh, Azad Library, Aligarh, Ms. No. Farsiyah Ulum 30.
37.	*Zij U. B.*	*Zij-i Ulugh Begi.* Mirza Ulugh Beg, Azad Library, Aligarh, Ms. No. Farsiyah Ulum 27.

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